KEW BULLETIN VOL. 63: 113–120 (2008)

An endangered new species of edible yam (*Dioscorea*, *Dioscoreaceae*) from Western Madagascar and its conservation

Paul Wilkin[1], Mamy Tiana Rajaonah[2], Vololoniaina Harimanga Jeannoda[2], Annette Hladik[3], Victor Louis Jeannoda[4] & Claude Marcel Hladik[3]

Summary. A new species of *Dioscorea* from Morondava prefecture in Western Madagascar is described. *Dioscorea bako* Wilkin differs from *D. alatipes* Burkill & H. Perr. by its usually shallowly and irregularly lobed leaf margins, broader leaf blade (grey-green below), longer petiole and the broadly cuneate area where the petiole is inserted onto the leaf blade in the basal sinus. It is pubescent, especially densely on young shoots and inflorescences. It is endemic to Morondava Préfecture and is endangered under IUCN Red List category criteria (IUCN 2001). The unusual morphological features of its inflorescences, some of which are shared with *D. alatipes* are discussed. *Dioscorea bako* is a favoured food source for people of the Menabe region and is reported by them to be increasingly hard to find. Immediate conservation measures are necessary to ensure that it remains extant and, in the medium to long term, research should be undertaken to guide its sustainable utilisation.

Key Words. conservation, *Dioscorea*, *Dioscorea bako*, *Dioscoreaceae*, Madagascar, yam.

Introduction

When carrying out fieldwork near Morondava in Western Madagascar with staff from the Parc Botanique et Zoologique de Tsimbazaza (February 2000), the first author found two sterile plants of an unusual *Dioscorea* species. These plants had irregularly lobed leaf margins, a broadly cuneate area in the leaf base sinus where the petiole is inserted onto the leaf blade, and a greyish-green underside to the blade. This combination of vegetative characters suggested that this was a species that was not included in the *Flore de Madagascar* treatment (Burkill & Perrier de la Bâthie 1950) and thus represented an undescribed taxon. The vegetative morphology suggested a possible relationship with *D. acuminata* Baker. Inhabitants of the region reported that its tuber is very good to eat and "as thick as your arm". In December 2002, the same taxon was collected in flower at the Réserve Speciale d'Andranomena by Mamy Tiana Rajaonah under the Sakalava name 'bako' and, in June of the following year, it was collected in fruit at Beroboka. These collections permitted detailed study of the species' inflorescence and floral morphology and revealed that it is an undescribed species related to *D. alatipes* Burkill & H. Perr., with which it shares an unusual inflorescence position and form. It is therefore described and illustrated below.

Materials and Methods

The *Yams of Madagascar* project has involved comparative morphological study and description in database records of 1,021 specimens from the following herbaria: B, BM, G, K, MO, P, TAN, TCD, TEF, WAG, UPS (abbreviations following *Index Herbariorum*: http://sciweb.nybg.org/science2/IndexHerbariorum.asp) and the Département de Biologie et Ecologie Végétales, University of Antananarivo, Madagascar (abbreviated as DBEV below). The specimens used in the study of *Dioscorea bako* are cited below. Floral dissections were carried out where appropriate and measurements made using a Leica MZ95 microscope with a measur-

Accepted for publication July 2007.

[1] Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, UK.
[2] Département de Biologie et Ecologie Végétales, Faculté des Sciences, Université d'Antananarivo, BP 906, Antananarivo 101, Madagascar.
[3] Éco-Anthropologie, CNRS & Muséum National d'Histoire Naturelle, 4 Avenue du Petit Château, 91800, Brunoy, France.
[4] Département de Biochimie Fondamentale et Appliquée, Faculté des Sciences, Université d'Antananarivo, BP 906, Antananarivo 101, Madagascar.

ing eyepiece. Vegetative and inflorescence characters were measured with a dial caliper. Conservation assessment data were prepared using ArcView 3.3 as part of a larger study of the conservation status and systematics of *Dioscorea* in Madagascar (Wilkin *et al.* in prep.).

Taxonomic Description

Dioscorea bako *Wilkin* **sp. nov.**, *D. alatipedi* Burkill & H. Perr. affinis sed praecipue surculis juvenibus et inflorescentiis pubescentibus; folia in sinu foliorum basali ad juncturam petioli laminaeque late cuneata; folia 2.6 – 7.7 cm lata (nec 1.0 – 2.5 cm lata) et petiolo 2.6 – 5.2 cm longo (nec 0.4 – 2 cm longo) differt. Typus: Madagascar, Toliara Province, Morondava Préfecture, Mahabo Subpréfecture, Réserve Spéciale d'Andranomena, ♂, fl. Dec. 2002, *Rajaonah* MT 006 (holotypus DBEV; isotypus K!).

A *twining vine* to at least 5 m, stems annual from a fleshy tuber. *Tubers* (Fig. 2A, B) annually replaced, those of current rainy season and previous rainy season present (e.g., Wilkin *et al.* 1137 and 1145), divergent, to c. 150 × 20 cm and 5.5 kg in weight when dug for food (Jeannoda *et al.* 2003; Rajaonah 2004), cylindric to fusiform or narrowly claviform, epidermis pale brown, parenchyma pure white, mucilaginous, crown white or pink, thickened, appearing to lack scales, c. 30 – 40 cm below the soil surface. *Indumentum* consisting of unicellular, straight to crisped simple hairs to 0.6 mm long, sparingly present on stems, more dense around nodes and on young vegetative growth, dense on peduncles and very dense on short specialised shoots bearing inflorescences and partial inflorescence bracts (Fig. 1C, D) so that the latter appear grey-brown when dry. *Stems* left-twining, to at least 8 mm in diameter in flowering individuals, terete, unarmed but roughened by means of russet-brown processes, and also black processes on older stems, white below ground, greyish-white towards base above it, green with greyish flecking above; cataphylls present towards stem base, to c. 1.5 cm long, narrowly ovate to elliptic or lanceolate, brownish-grey, chartaceous, apex acute to acuminate; bulbils not present. *Leaves* (Figs. 1A & 2A) alternate; blade 2.6 – 7.4 × 2.6 – 7.7 cm, shape variable, ovate or ovate-oblong to broadly so, rarely broadly reniform, chartaceous, mid- to dark matt green above, paler and greyish-green below, drying grey- or olive-brown, margins rarely entire, usually shallowly and irregularly lobed, base broadly cuneate at point of petiole insertion onto blade where main veins diverge (Fig. 2A, largest leaf), but overall shape shallowly to deeply cordate, sinus to 1.7 cm deep, apex acute or acuminate with a 2 – 5 mm long deltoid forerunner tip, concolorous with blade or slightly paler, veins 5, with a smaller, often bifid, vein to each basal lobe, sunk in depressions in blade in fresh material; petiole 2.6 – 5.2 cm long, terete but channelled on upper surface, shiny pale green, basal and apical pulvini slightly darker in herbarium specimens; lateral nodal flanges ('stipules' of Burkill 1960) present as an expansion of the petiole at its point of insertion onto the stem node and two reflexed fleshy projections on either side of the node. *Male inflorescences* (Fig. 1B) up to 12 per axil, on short specialised leafless shoots (to 2.5 cm long) in the axils of cataphylls towards stem base, two to three simple inflorescences per leaf axil above; partial/simple inflorescences with primary axis 1.5 – 9.5 cm long, peduncle (sterile basal region of partial inflorescence) 0.4 – 2.5 cm long, racemose, pendent, a few basal bracts relatively laxly distributed, but bracts dense and overlapping for most of the axis length and giving a catkin-like appearance; cymule bracts (Fig. 1D) 2.3 – 3 × 1.8 – 2.4 mm, borne on a ridged inflorescence axis concealed by bracts and flowers (Fig. 1C), sessile, broadly ovate to orbicular, thinly chartaceous with a single thickened midrib, apex strongly acuminate; each bract concealing a bracteole (Fig. 1D) orientated at 90° to the bract, bracteole 2 – 2.8 mm long, narrowly ovate to elliptic, membranous, with a thicker midrib, apex acuminate; bracteole subtending a sessile sterile flower (Fig. 1D), sessile sterile flower subtending in turn a cymule of (2 –)3(– 5) male flowers which are exserted from the bract (Fig. 1D), cymule primary branch 0.2 – 1.3 mm long, longitudinally ridged or flattened, floral bracts at each node of the cymule 0.7 – 1.2 mm long, smaller towards cymule apex, ovate to lanceolate, glabrous, membranous, sometimes with a fine midrib. *Female infructescences* (Fig. 2C) one per axil, simple, spicate, pendent; peduncle 38 – 53 mm long, narrower than axis but thickening towards apex, flattened and two-winged; axis 60 – 90 × 0.9 – 1.8 mm, ridged and angled, capsules solitary, c. 2 – 10 mm apart, denser towards apex where capsules overlap for much of their length, ovaries often aborted towards base. *Sterile flowers* with a c. 1.4 × 0.9 mm, swollen, obovoid receptacle possessing several raised longitudinal ridges; tepals 1.5 – 2.7 mm long, thickened and opaque in dried material, narrowly elliptic, lanceolate or narrowly elliptic-oblong, erect, apices sometimes extended, membranous and with similar pubescence to cymule bracts, especially in outer whorl, or rounded to obtuse, weakly developed staminodia and pistillodia sometimes present inside flower. *Fertile male flowers* (Fig. 1E – G) yellow, scent not recorded, on pedicels 0.6 – 1.5 mm long, longitudinally ridged and slightly thickened towards apex; tepals 6, in two whorls, ±free, ascending (Fig. 1G), margins membranous, central area thickened and reticulate in appearance, with a fine midrib, tepals inserted on a flat, thin discoid torus c. 0.8 mm in diam., outer whorl 1.1 – 1.4 × 0.5 – 0.8 mm, elliptic or ovate to narrowly so, apex acute, inner whorl 0.9 – 1.1 × 0.5 – 0.8(– 0.9) mm, elliptic to elliptic-oblong, apex

Fig. 1. *Dioscorea bako* vegetative and male floral morphology. **A** habit, showing the leaves and one of the uppermost inflorescences in the axil of a vegetative branch; **B** stem towards its base, showing the dense inflorescences on short specialised leafless shoots in the axils of cataphylls; **C** section of an inflorescence, showing the cymule bracts and flowers concealing the axis; **D** single cymule, showing its insertion on part of the axis, a cymule bract and bracteole (pubescent), the sessile sterile flower at the cymule base and two open flowers on the cymule with their pedicels; **E** flower in the process of opening, side view; **F** open flower, top view , showing the two whorls of stamens; **G** a half-flower (longitudinal section) showing the discoid torus and the insertion of the tepals on to it. **A** from *Rajaonah* MT 057, **B** – **G** from *Rajaonah* 006. Scale bar: **A**, **B** 2.5 cm; **C** 3.3 mm; **D** 1.7 mm; **E** – **G** 1.2 mm. DRAWN BY LUCY SMITH.

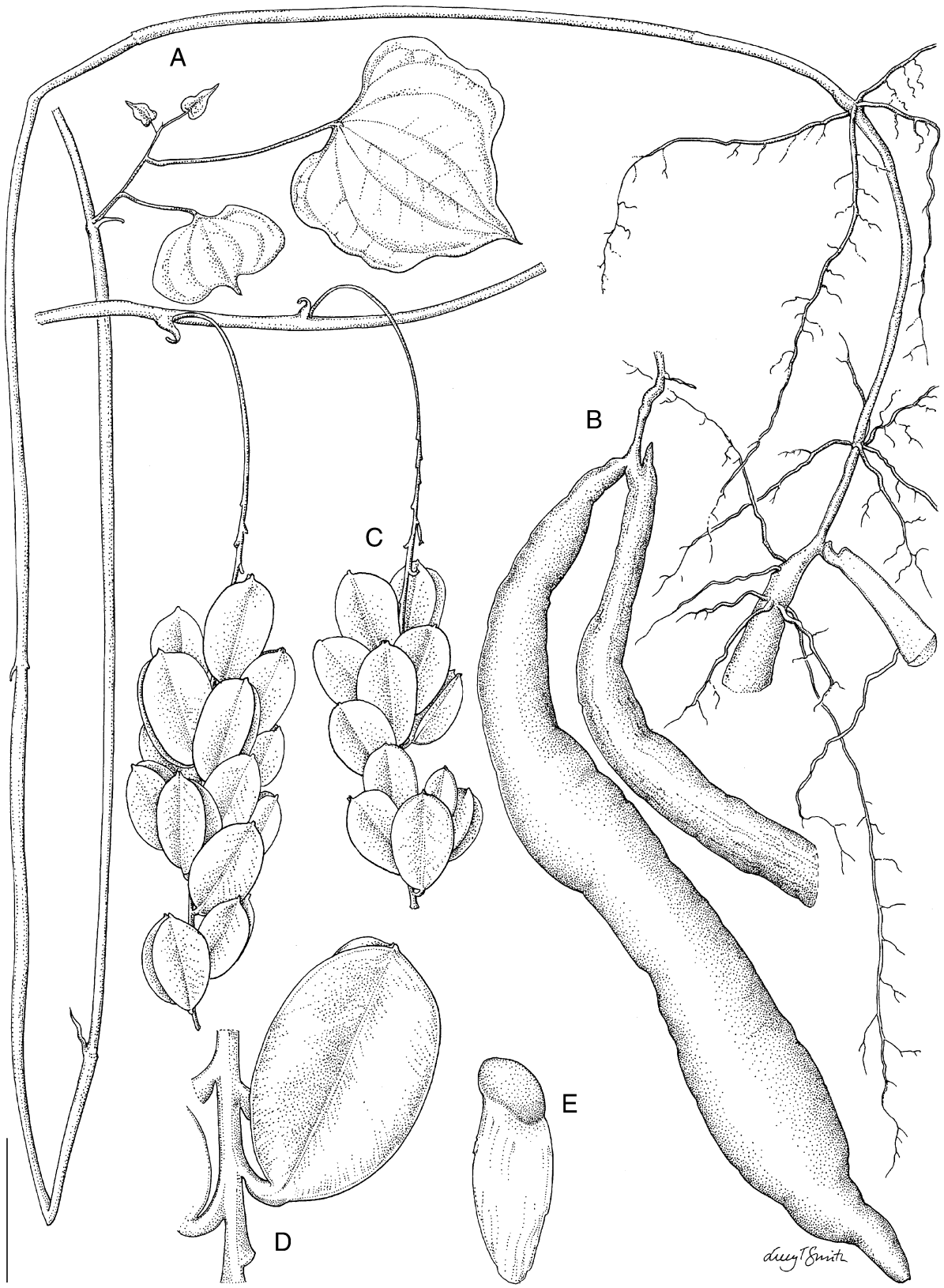


Fig. 2. *Dioscorea bako* underground organ and female fruiting morphology. **A** habit, showing the upper part of the tubers, below- and above-ground parts of the lower stem with cataphylls and the first vegetative branch with developing leaves; **B** tuber, with the upper part of the previous rainy season's tuber; **C** two infructescences, showing the capsule shape and orientation at maturity; **D** capsule, showing the stipe; **E** seed, showing the basal wing. All from *Rajaonah* s.n. Scale bar: **A** 3 cm; **B** 8 cm; **C** 2.5 cm; **D**, **E** 1 cm. DRAWN BY LUCY SMITH.

obtuse, stamens (Fig. 1F, G) erect, filaments very short, to 0.2 mm long , anthers 0.2 – 0.4 × 0.2 – 0.4 mm, oblong-orbicular, basifixed; pistillode absent. *Female flowers* unknown. *Capsules* (Fig. 2C, D) reflexed at maturity at c. 30 – 45° to axis, (17 –)19 – 22 × (9.5 –) 11 – 13 mm, narrowly obovate to narrowly obovate-oblong in outline, pale tan with many small dark to very dark brown markings, especially on axis and towards margin, base rounded to broadly cuneate, apex rounded to acute with a projection (floral remains) on each valve; capsular stipes 1.6 – 2.5 mm long, obdeltoid, three-angled, reflexed. *Seeds* (Fig. 2E) winged at base only, 4.6 – 5.5 × 3.2 – 4 mm, flattened ovoid-lenticular to subreniform-lenticular, matt brown, wing (8.3 –) 10 – 12.5 × 4.8 – 6 mm (upper seed of two in each locule has shorter wing), oblong to narrowly ovate, apex obtuse to rounded, golden-brown, translucent. Figs. 1 & 2.

DISTRIBUTION. Endemic to Morondava Préfecture in Western Madagascar, currently known from Réserve Spéciale d'Andranomena, Kirindy Forest and the surrounding area (see Map 1). *Dioscorea alatipes* is also a narrow endemic found only near Toliara on limestone or sandy soils. In July 2006, while this paper was being drafted, further individuals of *D. bako* were encountered by V. Jeannoda, but not collected, in the southern part of Menabe, in the commune of Ampanihy, south of the Kabatomena river and the town of Mahabo.

MADAGASCAR. Toliara Province: Morondava Préfecture, Mahabo Subpréfecture, Réserve Spéciale d' Andranomena, old ♂ fl., Feb. 2003, *Rajaonah* MT 056 (P); same location, old ♂ fl., Feb. 2003, *Rajaonah* MT 057 (DBEV, K!); Beroboka, ♀ fr., June 2003, *Rajaonah* MT s.n. (DBEV, K!); Kirindy Forest, Sentier Botanique 2, S20°04′13″ E44°38′23″, sterile, 20 Feb. 2000, *Wilkin*, *Rakotonasolo & Davis* 1137 (K!, TAN!); Morondava Préfecture, Belo-sur-Tsiribinha Subprefecture, Route de Belo-sur-Tsiribinha à Morondava, S 19°55′6″ E44°36′00″, sterile, 22 Feb. 2000, *Wilkin*, *Rakotonasolo & Davis* 1145 (K!, TAN!).

VERNACULAR NAME: Bako (Sakalava).

ECOLOGY. Deciduous forest on sandy, loamy, lateritic or stony soils, sometimes in partially disturbed areas or light gaps but also encountered in deep shade and in wetter habitats. Altitude c. 20 m. Flowering from December to February, capsules dehiscing in June or July. In research on the yams of the Morondava region (as part of a paper on the diversity, cultural role, management and nutritional value of the yams of Madagascar [Jeannoda *et al.*, pers. comm.]), *Dioscorea bako* was shown to be one of 10 species encountered there. This species was found infrequently at Andranomena in partially logged deciduous forest on very sandy loam soils, and in much greater abundance at Beroboka in a cultivated area on sandy clay soil near water. The recently discovered population(s) at Ampanihy showed the same ecological preferences.

CONSERVATION STATUS. IUCN Red List category EN B2b(iii)(iv)C (IUCN 2001). The four localities of the five specimens cited above give an extent of occurrence (EOO) of 137.5 km^2. At a cell size of 3.116 km^2 (see Willis *et al.* 2003 for a discussion of the importance of cell size), *Dioscorea bako* occupies four cells with an area of occupancy (AOO) of 38.84 km^2 and has four sub-populations based on grid adjacency. If a cell size of 10 km^2 is used (the software can overestimate cell size near coastlines), *D. bako* has an AOO of 300 km^2 with two subpopulations based on grid adjacency. All of the above measures indicate that it is Endangered. Rapoport Analysis (Rapoport 1982) gives an AOO of 1,010.03 km^2 and two subpopulations. The discovery of the species in July 2006 in the commune of Ampanihy will increase the EOO and AOO of the species, but is unlikely to do so sufficiently to place it in a different IUCN Red List category.

USES. The tuber of *Dioscorea bako* is edible and, with *D. maciba* Jum. & H. Perr., is the favoured yam of people of the Morondava region (Jeannoda *et al.* 2003, 2007; Rajaonah 2004). The tubers, which reach maturity in April, are peeled, washed, and cut into c. 12 – 20 or 2 – 4 cm long pieces. These are boiled in water deep enough to cover them and served with either fish or honey as a main meal or alone as a snack. The larger pieces are called *sambaiky* in Sakalava when cooked, whereas the smaller, which have a softer consistency, are called *katokato* (Rajaonah 2004).

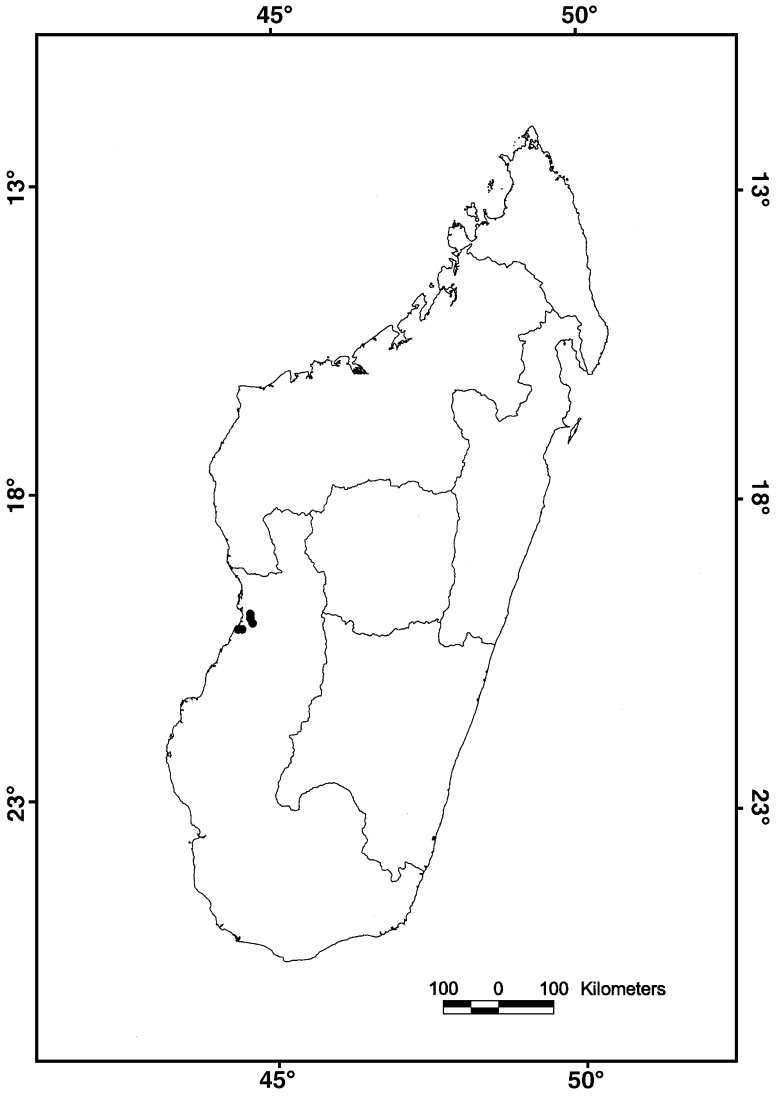
NOTES. The type specimen has no leaves. This is unfortunate, but it is the only currently available specimen that has flowers at anthesis. The Sakalava name *Bako* was selected as the specific epithet for this species in order to preserve the Malagasy name of this plant and to continue the tradition established by Perrier of formalising vernacular names for Malagasy taxa of *Dioscoreaceae*. It can be recognised in the field by its leaf blades, which have shallowly and irregularly lobed margins, are grey-green below, and are broadly cuneate at the point of petiole insertion, and by its male inflorescences, which are borne towards the stem base with dense, overlapping, pubescent bracts.

Inflorescence morphology

The inflorescence of *Dioscorea bako* is unusual in a number of respects. First, fertile branches are mainly borne close to soil level on short specialised leafless shoots in the axils of cataphylls, towards the stem base where true leaves are absent (Figs. 1B and 2C). This inflorescence position is unique among *Dioscorea* species to *D. bako* and its close relative *D. alatipes,* although the latter lacks the short leafless shoots that make the inflorescence of *D. bako* compound. *Dioscorea alatipes* has a gemmate pollen ektexine morphology, which may be related to ant pollination in

Dioscorea (Schols *et al.* 2003, 2005). The pollen morphology of *D. bako* has not yet been studied.

In the male inflorescence of *Dioscorea bako*, the bracts are relatively large and dense, concealing the axis for most of its length (Fig. 1C). This is similar to the inflorescence of *D. alatipes*, and to the much more distantly related African compound-leafed species *D. quartiniana* A. Rich. Flowers of the latter are solitary in the axil of each floral bract, whereas *D. bako* and *D. alatipes* possess a cymule in the axil of a bract and bracteole at each node of the axis. Burkill (1960) regarded the switch from a single flower on a raceme or spike to a cymule as a means of maximising male reproductive investment. Such cymulose inflorescences were called drepania by Weberling (1989). Evidence that drepania have evolved from racemose and spicate partial inflorescences is found in the bract and/or bracteole at the base of each cymule, which appears to be homologous with the floral bract and bracteole of the latter inflorescence type. The phylogenetic tree obtained by Wilkin *et al.* (2005) suggests that this change has occurred many times in the genus *Dioscorea*, across its geographical range and in most of the main subclades. Other Malagasy endemic species with drepania include *D. sterilis* Weber & Wilkin (Weber *et al.* 2005), *D. maciba* Jum. & H. Perr. (Burkill & Perrier de la Bâthie 1950), *D. sambiranenisis* R. Knuth (Burkill & Perrier de la Bâthie 1950), *D. namorokensis* Wilkin (Wilkin *et al.* 2002), *D. bemarivensis* Jum. & H. Perr. (Haigh *et al.* 2005) and *D. arcuatinervis* Hochr. (Burkill & Perrier de la Bâthie 1950). Both the tree described in Wilkin *et al.* (2005) and the diversity



Map 1. Distribution of *Dioscorea bako* in Madagascar.

of other morphological characters in these taxa indicate that there has been more than one origin of drepania in Madagascar alone.

The third unusual aspect of the male inflorescence of *Dioscorea bako* is the presence of sterile flowers at the base of each cymule (see Fig. 1D and description above). The receptacular base was checked for ovules in the available specimens of *D. bako*: none were found. Staminodia and pistillodia were either absent or very weakly developed and thus unlikely to enable sexual reproduction to take place. Such sterile flowers are unique to the Malagasy species *D. bako*, *D. alatipes* (pers. obs.) and *D. sterilis* (Weber *et al.* 2005). Their role needs investigation, but it is possible that they are sacrificial and attract invertebrate herbivores away from the functional male flowers. The sterile flowers of *D. sterilis* are pedicellate, whereas in *D. bako* and *D. alatipes* they are sessile with the tepals borne on an obovoid structure that appears to be derived from the receptacle. The reproductive biology of these three species would make an excellent study.

Conservation and sustainable use

This yam species is a particularly important local food resource in the Menabe region of Madagascar, and thus its conservation status needs to be understood and monitored to ensure its sustainable utilisation. *Dioscorea bako* has a very restricted distribution but its desirability as a starch source and knowledge of its use is equal to that of *D. maciba* Jum. & H. Perr. (Rajaonah 2004), a species that is common and widespread in Western Madagascar. Currently available data indicate that *D. bako* is endangered (see above). People in the region report anecdotally that it is rare and that the numbers of *bako* plants have reduced markedly in recent years through a high level of extraction (Rajaonah 2004). Habitat loss represents a further threat to this species. Therefore *D. bako* is an ideal candidate for a detailed study of its autecology and for sustainable levels of extraction to guide its future exploitation. Given its rarity and apparent recent decline, however, it is appropriate to suggest that immediate measures should be taken to protect the species either *in* or *ex situ* (or using both strategies). The Réserve Spéciale d'Andranomena and the contiguous protected area at Kirindy could provide a sanctuary for the species to ensure its survival.

In recent years, an important development has occurred in yam extraction in Menabe: the community has increased its awareness of the need to refill the holes made when digging up wild yams with soil and to rebury the crown and apex of the tuber. This ensures that the plant will grow again the following year in the same place. Mamy Tiana Rajaonah, together with the Département de Biologie et Ecologie Végétales of the Université d'Antananarivo and the Swiss NGO SAHA, have been responsible for this important work. Two campaigns that have had significant cooperation from the local community have also been undertaken in Beroboka with the aim of increasing the cultivation and use of domesticated yams such as *Dioscorea alata* L. It is hoped that this will reduce the pressure on wild yam species, especially *D. bako*. The Conservation NGO Fanamby has been helping in this project. Initial attempts at cultivation have proved only moderately successful, but we believe that growing *D. bako* around human settlements will be a vital part of any successful management plan. It is to be hoped that the above initiatives, with others now at the planning stage, will ensure a sustainable future for *D. bako*.

Acknowledgements

Thanks are due to the Département des Eaux et Fôrets in Antananarivo for granting collecting permits, and to all those at Parc Botanique et Zoologique de Tsimbazaza, Antananarivo who helped with research and fieldwork. Thanks are also due to the FADES Project (Fonds d'Appui au Développement de l'Enseignement Supérieur), which funded all the research undertaken by the Département de Biologie et Ecologie Végétales on Yams, in particular the field work of Mamy Tiana Rajaonah in the Menabe region. The COLPARSYST programme provided financial support for a visit by PW to the Museum National d'Histoire Naturelle in Paris in October 2003, and the SYNTHESYS programme funded a further visit in October 2006; PW would like to thank Leandro Leoz and all the staff of the Laboratoire de Phanerogamie for their help, especially Jean-Noel Labat and Thierry Deroin. Dave Simpson's constructive comments improved an earlier version of this manuscript. Odile Weber and Justin Moat prepared the conservation assessment and distribution map. Mark Coode corrected the Latin diagnosis.

References

Burkill, I. H. (1960). The organography and the evolution of the *Dioscoreaceae*, the family of the yams. J. Linn. Soc., Bot. 56: 319 – 412.

Burkill, I. H. & Perrier de la Bâthie, H. (1950). *Dioscoréacées*. In: H. Humbert (ed.), Flore de Madagascar et des Comores. Muséum National d'Histoire Naturelle, Paris.

Haigh, A., Wilkin, P. & Rakotonasolo, F. (2005). A new species of *Dioscorea* L. (*Dioscoreaceae*) from western Madagascar and its distribution and conservation status. Kew Bull. 60: 273 – 281.

IUCN (2001). IUCN Red List Categories: Version 3.1. Prepared by the IUCN Species Survivial Commission, Gland, Switzerland.

Jeannoda, V., Jeannoda, V. H., Hladik, A. & Hladik, C. M. (2003). Les ignames de Madagascar; diversité, utilisations et perceptions. Hommes et Plantes 47: 10 – 23.

____, Razanamparany, J., Rajaonah, M. T., Monneuse, M. O., Hladik, A. & Hladik, C. M. (2007). Les ignames (*Dioscorea* spp.) de Madagascar: espèces endémiques et formes introduites; diversité, perception, valeur nutritionnelle et systèmes de gestion. Rev. Ecol. (Terre et Vie) 62: 191 – 207.

Rajaonah, M. T. M. (2004). Études Biologique, Anatomique, Ecologique et Ethnobotanique des espèces de *Dioscorea* (*Dioscoreaceae*) dans la region du Menabe. Unpublished DEA thesis, Département de Biologie et Ecologie Végétales, Faculté des Sciences, Université d'Antananarivo.

Rapoport, E. H. (1982). Areography: Geographical Strategies of Species. Pergamon Press, New York.

Schols, P., Furness, C. A., Wilkin, P., Smets, E., Cielen, V. & Huysmans, S. (2003). Pollen morphology of *Dioscorea* (*Dioscoreaceae*) and its relation to systematics. Bot. J. Linn. Soc. 143: 375 – 390.

____, Wilkin, P., Furness, C. A., Huysmans S. & Smets, E. (2005). Pollen evolution in yams (*Dioscorea*, *Dioscoreaceae*). Syst. Bot. 30: 750 – 758.

Weber, O., Wilkin, P. & Rakotonasolo, F. (2005). A new species of edible yam (*Dioscorea* L.) from western Madagascar. Kew Bull. 60: 283 – 291.

Weberling, F. (1989). Morphology of Flowers and Inflorescences. Cambridge University Press, Cambridge.

Wilkin, P., Rakotonasolo, F., Schols, P., & Furness, C. A. (2002). A new species of *Dioscorea* (*Dioscoreaceae*) from Western Madagascar and its pollen morphology. Kew Bull. 57: 901 – 909.

____, Schols, P., Chase, M. W., Chayamarit, K., Furness, C. A., Huysmans, S., Rakotonasolo, F., Smets, E. & Thapyai, C. (2005). A plastid gene phylogeny of the yam genus, *Dioscorea*: roots, fruits and Madagascar. Syst. Bot. 30: 736 – 749.

Willis, F., Moat, J. & Paton, A. (2003). Defining a role for herbarium data in Red List assessments: a case study of *Plectranthus* from eastern and southern Africa. Biodivers. Conserv. 12: 1537 – 1552.